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## PICTORIAL ESSAY

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# The Incremental Value of Single-photon Emission Computed Tomography / Computed Tomography in Post-thyroidectomy Iodine-131 Scanning of Differentiated Thyroid Carcinoma. Part II: Pictorial Illustration

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### ABSTRACT

*This pictorial essay illustrates how iodine-131 single-photon emission computed tomography / computed tomography (SPECT/CT) fusion imaging might improve the interpretation of planar iodine-131 whole-body images in post-surgical patients with differentiated thyroid carcinoma. Examples are given to illustrate how SPECT/CT fusion images can enhance anatomical localisation of increased uptake identified on planar images, and thus enable differentiation of physiological uptake and artefacts from metastatic uptake, exclude false-positive findings, and confirm true-positive findings and, hence, affect the clinical decision on further therapeutic treatment in this group of patients.*

*Key Words:* Image processing, computer-assisted; Iodine radioisotopes; Thyroid neoplasms; Tomography, emission-computed, single-photon

## 中文摘要

### 分化型甲狀腺癌患者甲狀腺切除術後使用SPECT/CT 掃描偵測放射性碘 (I-131) 的優勢：第二部份：圖像闡釋

鄧蕙碧、王琪、張智欣、梁承暉

本文透過圖像解釋單光子發射電腦斷層攝影/電腦斷層攝影 (SPECT/CT) 融合顯像如何能改善分化型甲狀腺癌患者甲狀腺切除術後I-131平面全身顯像的解讀。並會舉例說明SPECT/CT融合圖像如何讓平面顯像發現的I-131濃聚灶解剖定位更準，從而能將生理性濃聚和偽影與轉移腫瘤的濃聚區分開來；排除假陽性結果並確定真陽性結果，從而改變醫生的下一步治療策略。

### INTRODUCTION

As previously detailed in part I of this article,<sup>1</sup> a multitude of imaging modalities have been used for

long-term follow-up of patients with differentiated thyroid carcinoma, with conventional planar iodine-131 (<sup>131</sup>I) whole-body scintigraphy in association with

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serum thyroglobulin measurement remaining as the routine diagnostic procedure. However, there are multiple factors that limit performance of this procedure. The use of an integrated single-photon emission computed tomography / computed tomography (SPECT/CT) system permits simultaneous anatomic mapping and functional imaging, thereby greatly improving the accuracy of the procedure in several respects, as will be illustrated in this article.

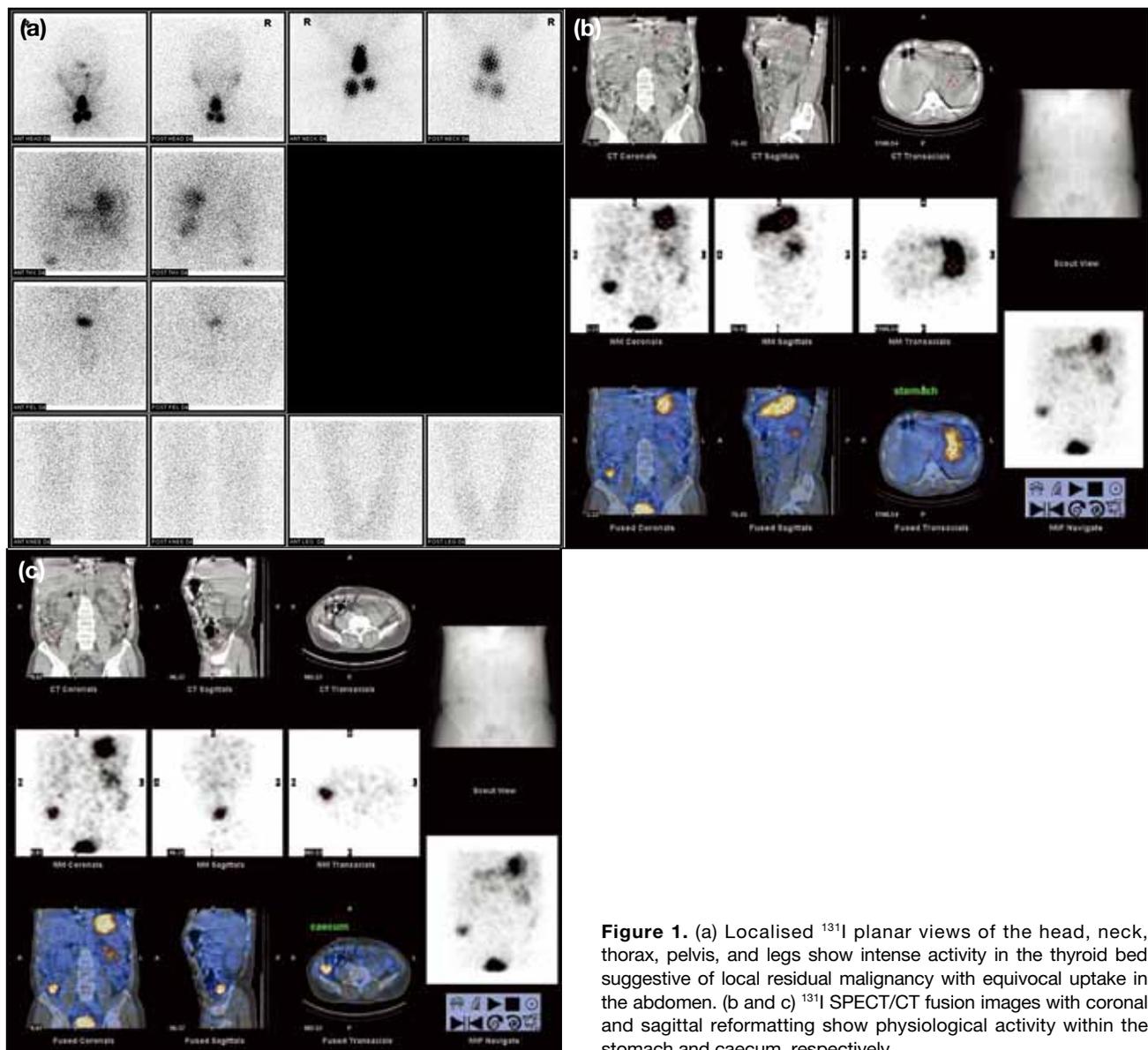
### USE OF AN INTEGRATED SPECT/CT SYSTEM IN IMPROVING ACCURACY

Intense uptake in neck on postoperative RAI scan could be due to residual local normal thyroid tissue, while residual or recurrent thyroid malignancy is difficult

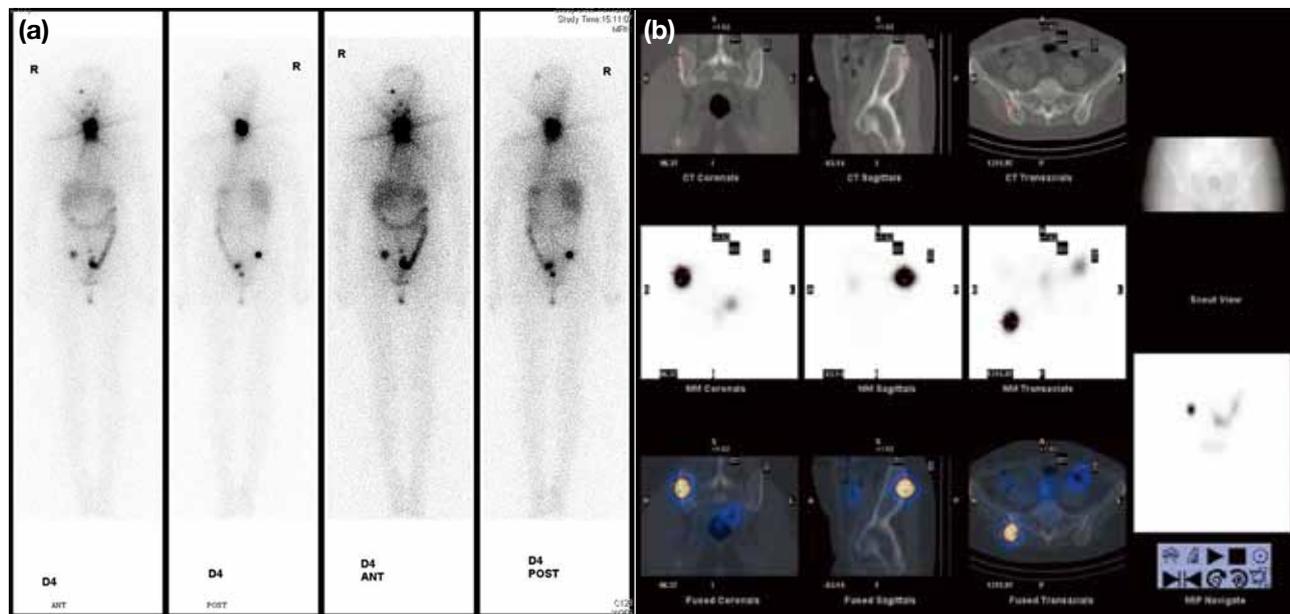
to exclude as it may not be totally resected by total thyroidectomy.

The use of an integrated SPECT/CT system enables exclusion of distant metastasis (Figure 1), differentiation of pathological versus physiological uptake (Figure 2), improvement of specificity and diagnostic accuracy of pathological uptake (Figures 3 to 6), and identification of artefacts that may mimic pathological uptake (Figures 7 and 8).

Figure 1 shows a 59-year-old man who had undergone total thyroidectomy for papillary carcinoma. Localised <sup>131</sup>I planar views over the neck, thorax, pelvis, and legs showed intense activity in the thyroid bed suggestive of



**Figure 1.** (a) Localised <sup>131</sup>I planar views of the head, neck, thorax, pelvis, and legs show intense activity in the thyroid bed suggestive of local residual malignancy with equivocal uptake in the abdomen. (b and c) <sup>131</sup>I SPECT/CT fusion images with coronal and sagittal reformatting show physiological activity within the stomach and caecum, respectively.



**Figure 2.** (a) Whole-body biplanar scintigraphy shows a blooming artefact in the thyroid bed suggestive of residual malignancy, intense uptake in the right fronto-orbital and left posterior parietal bones of the skull suspicious of metastases, and equivocal intense uptake in the right lower quadrant of the abdomen. (b)  $^{131}\text{I}$ -SPECT/CT fusion images show distant bony metastasis in the right posterior ilium.

local residual malignancy, with equivocal uptake in the abdomen.  $^{131}\text{I}$ -SPECT/CT fusion images with coronal and sagittal reformatting showed only physiological activity within the stomach and caecum.

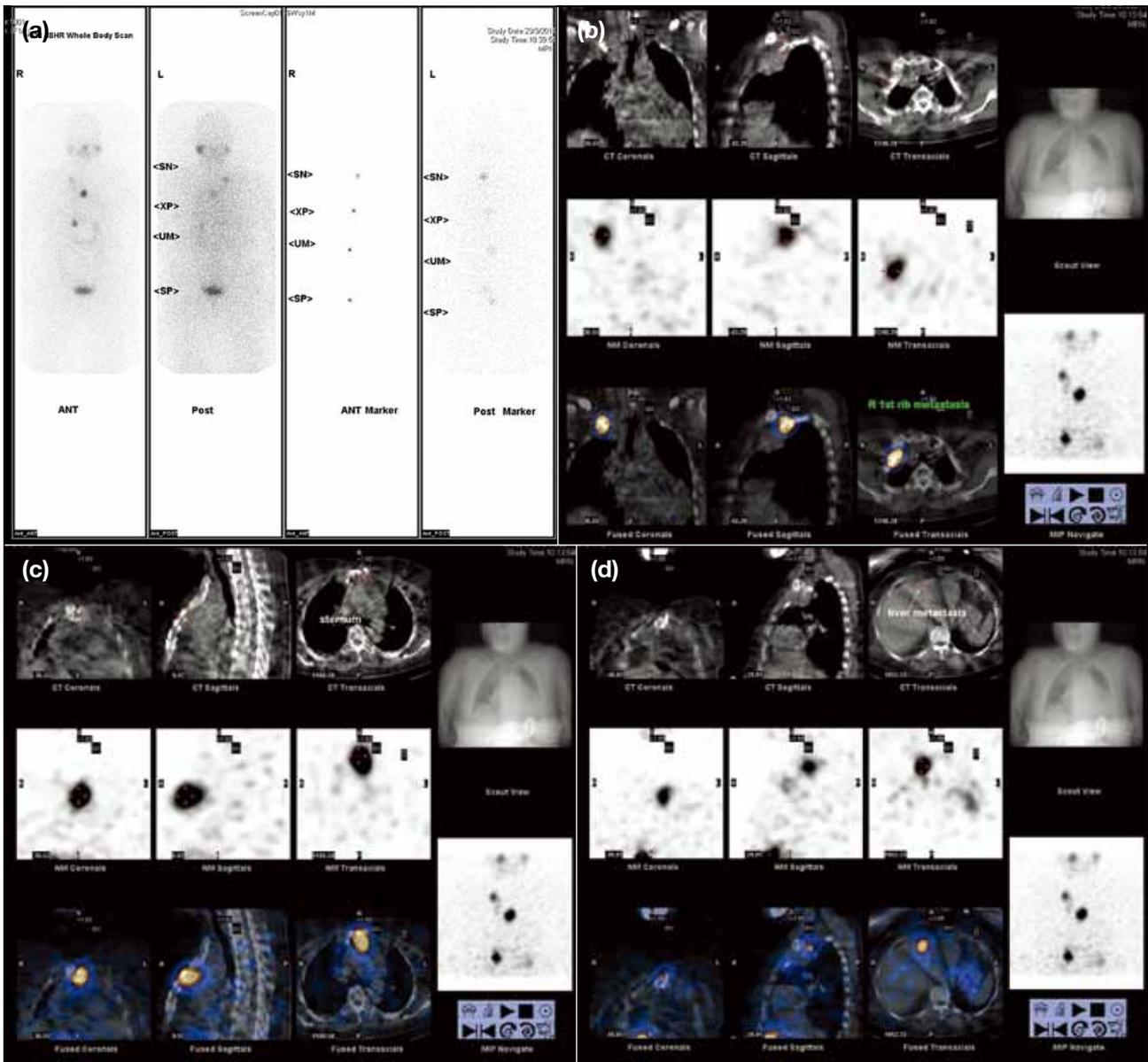
A 30-year-old woman with a history of follicular carcinoma had undergone complete thyroidectomy. Whole-body biplanar scintigraphy showed a blooming artefact in the thyroid bed suggestive of residual malignancy, intense uptake in the right fronto-orbital and left posterior parietal bones of the skull suspicious of metastases, and equivocal intense uptake in the right lower quadrant of the abdomen (Figure 2).  $^{131}\text{I}$ -SPECT/CT fusion images confirmed distant bony metastasis to the right posterior ilium. This led to a subsequent change in the therapeutic strategy with the decision to administer another therapeutic dose of  $^{131}\text{I}$ .

An 88-year-old woman who underwent thyroidectomy for follicular thyroid carcinoma had progressive disease postoperatively and underwent multiple ablative radioactive iodine treatment. A low-dose diagnostic  $^{131}\text{I}$  (111 MBq) whole-body biplanar scan was done for evaluation of the metastatic disease, which showed abnormal uptake in the chest and abdomen (Figure 3). The exact anatomical localisation of these foci of uptake was delineated on SPECT/CT fusion images, confirming metastases in the right first rib end, sternum,

and left lobe of the liver. These findings prompted the management decision for further ablative radioactive iodine therapy, but the patient refused further treatment. She died of respiratory failure from multilobar pneumonia shortly afterwards.

A 79-year-old man who underwent thyroidectomy for papillary thyroid carcinoma was referred for  $^{131}\text{I}$  therapy (3 GBq). High-dose localised planar views showed intense activity in the neck, suggestive of local residual malignancy, with equivocal uptake in the chest (Figure 4). Based on the planar images, it was unclear whether this uptake was pulmonary or mediastinal in origin.  $^{131}\text{I}$ -SPECT/CT fusion images delineated that the activity was localised to the posterior mediastinum, in the region of the mid-oesophagus, and was suspicious for metastasis. Consequent to these findings, it was decided to administer another ablation dose of  $^{131}\text{I}$ .

A 35-year-old woman had been diagnosed with locally advanced papillary thyroid carcinoma at the age of 9 years, and underwent thyroidectomy and neck dissection in 1984. She had a chronic relapsing and remitting disease course, with lung and paraspinal metastases treated with surgical decompression, posterior spinal fusion, and external radiotherapy. Due to progressively elevating thyroglobulin levels on follow-up, the patient underwent a low-dose diagnostic  $^{131}\text{I}$  (111 MBq)

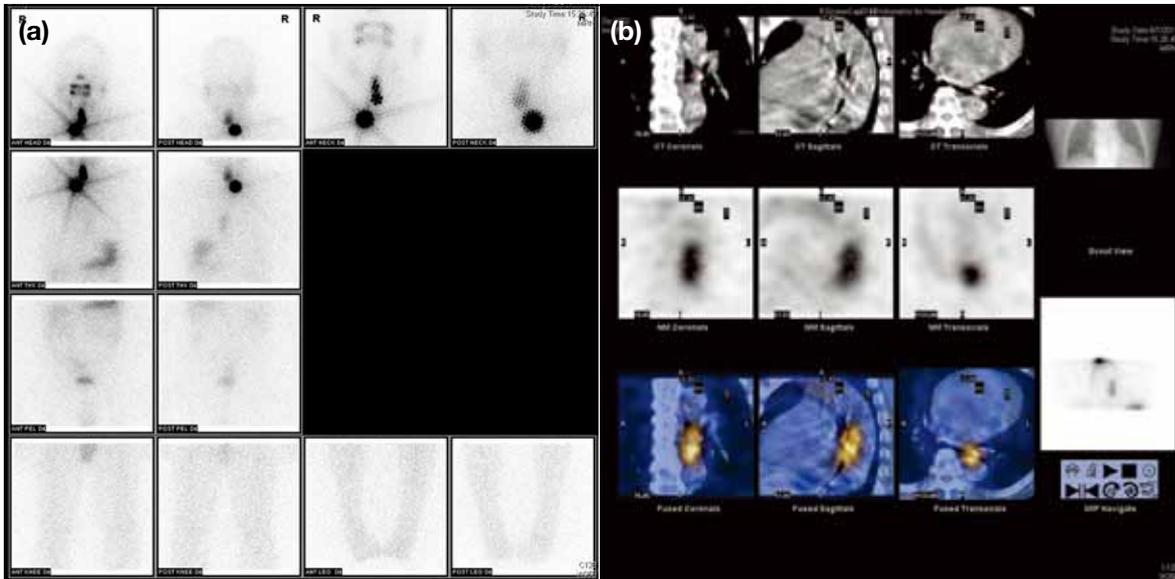


**Figure 3.** (a) Low-dose diagnostic  $^{131}\text{I}$  (111 MBq) whole-body biplanar scans for evaluation of metastatic disease show abnormal uptake in the chest and abdomen. (b to d) SPECT/CT fusion images show metastases in the right first rib end, sternum, and left lobe of the liver, respectively.

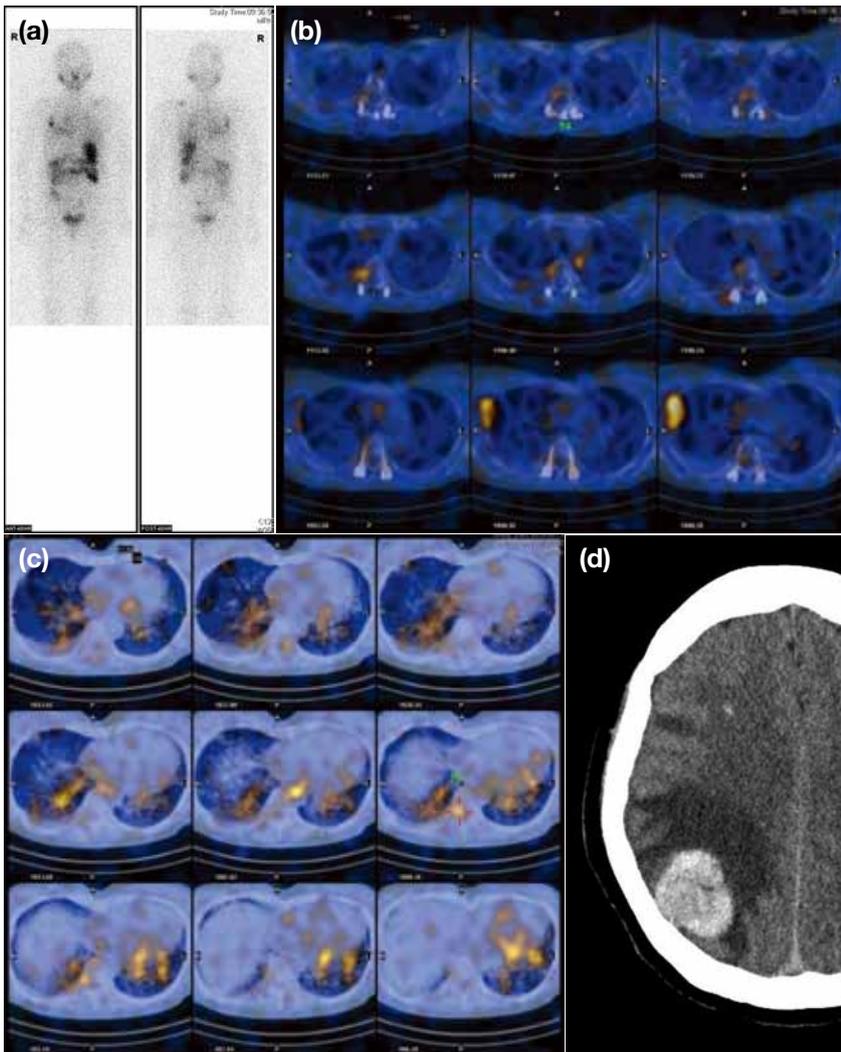
study to check for disease recurrence or metastasis. Biplanar whole-body scan showed no evidence of local recurrence, but there was suspicious uptake in the left shoulder and right side of the head, with equivocal uptake in the right hemithorax and thoracic spine (Figure 5). SPECT/CT was performed, which showed lytic metastasis in the right fourth rib with T4 vertebral metastasis, disseminated lung metastasis, and T9 vertebral metastasis. Non-contrast CT of the brain also confirmed hyperdense metastases to both cerebral hemispheres, the largest lesion being in the right parietal lobe. These findings altered the treatment plan

to administration of another ablative  $^{131}\text{I}$  dose (3.7 GBq) and whole-brain radiotherapy shortly afterwards.

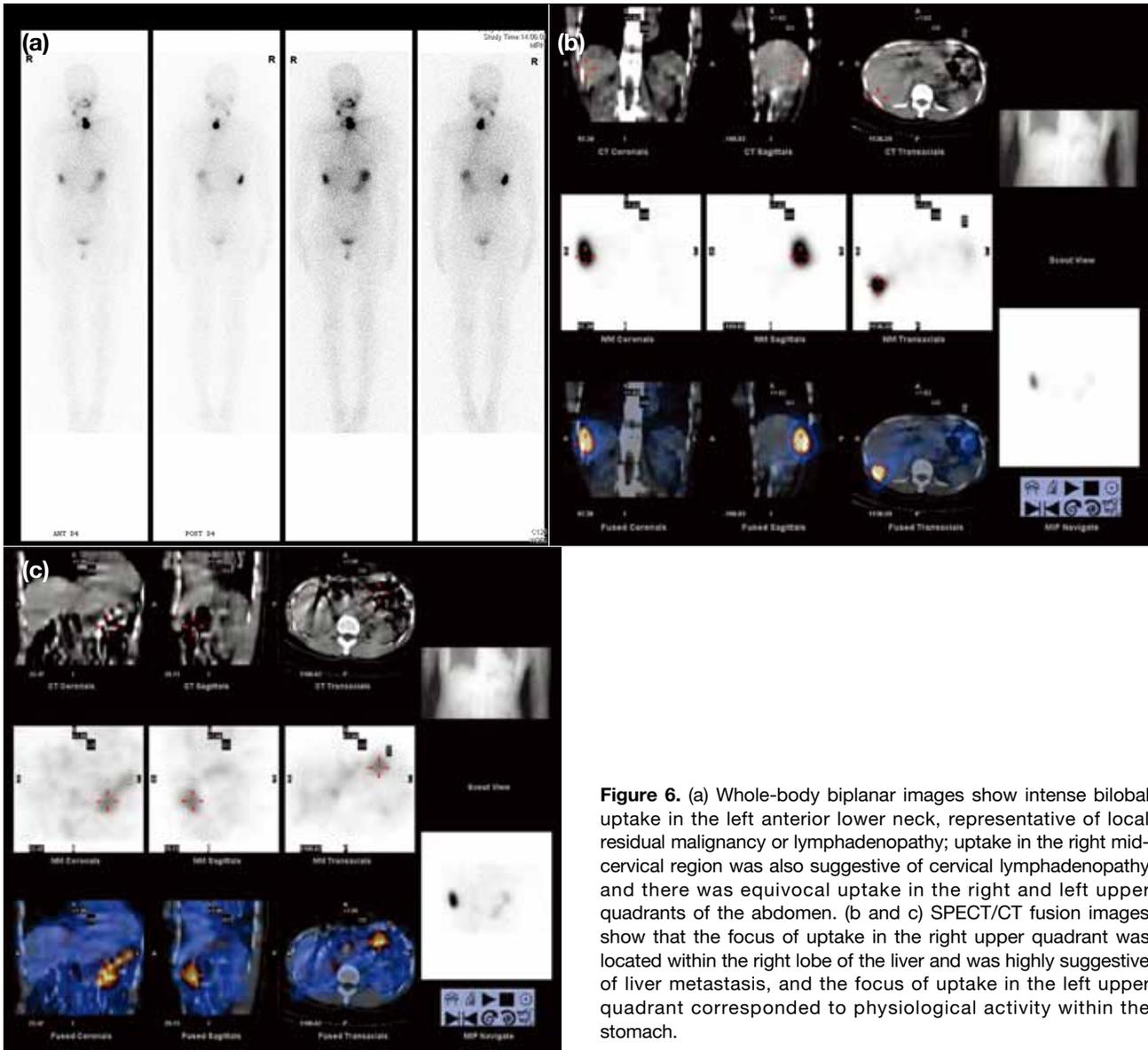
A 58-year-old man with thyroidectomy underwent central neck dissection for papillary thyroid carcinoma. High-dose whole-body scan was performed on day 4 after a therapeutic dose of  $^{131}\text{I}$  (3 GBq) was administered (Figure 6). Whole-body biplanar images showed intense bilobar uptake in the left anterior lower neck, which was likely to represent local residual malignancy or lymphadenopathy. Uptake in the right mid-cervical region was also suggestive of cervical



**Figure 4.** (a) High-dose localised planar views show intense activity in the neck suggestive of local residual malignancy with equivocal uptake in the chest. (b)  $^{131}\text{I}$  SPECT/CT fusion images show that the activity was localised to the posterior mediastinum in the region of the mid-oesophagus, and was suspicious for metastasis.



**Figure 5.** (a) Biplanar whole-body scans show no evidence of local recurrence, and suspicious uptake in the left shoulder and right side of the head, with equivocal uptake in the right hemithorax and thoracic spine. (b and c) SPECT/CT images show lytic metastasis in the right fourth rib with T4 vertebral metastasis, disseminated lung metastasis, and T9 vertebral metastasis, respectively. (d) Non-contrast CT image of the brain shows hyperdense metastases to both cerebral hemispheres, with the largest lesion in the right parietal lobe.

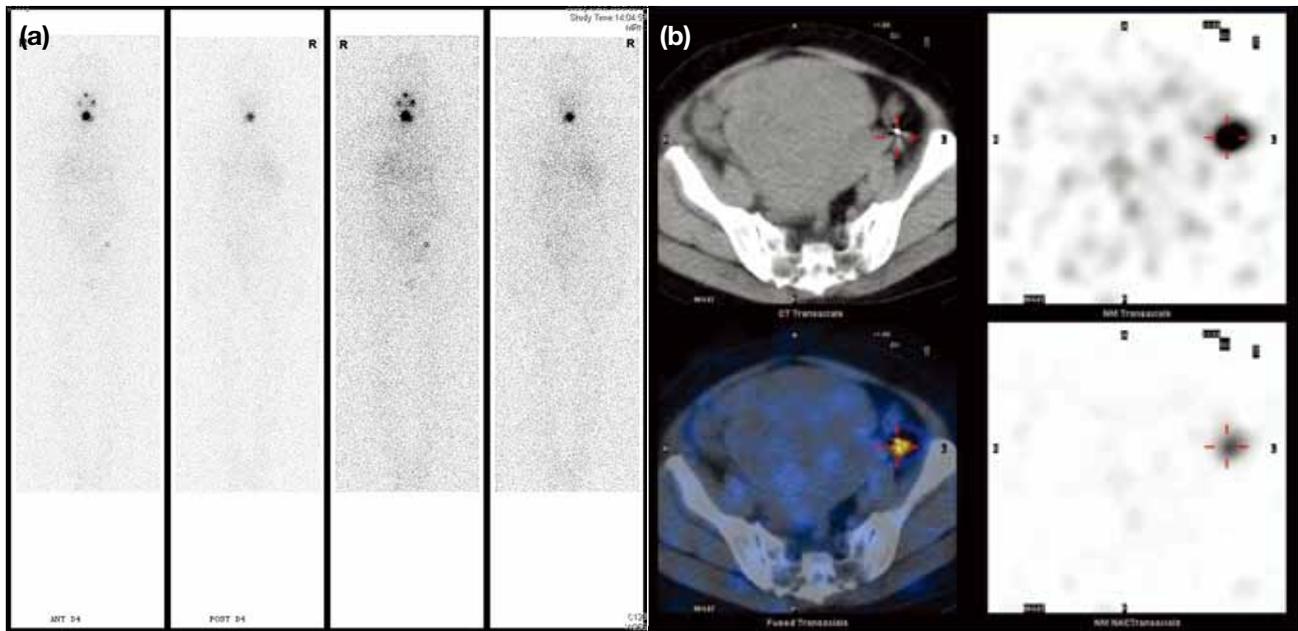


**Figure 6.** (a) Whole-body biplanar images show intense bilobal uptake in the left anterior lower neck, representative of local residual malignancy or lymphadenopathy; uptake in the right mid-cervical region was also suggestive of cervical lymphadenopathy and there was equivocal uptake in the right and left upper quadrants of the abdomen. (b and c) SPECT/CT fusion images show that the focus of uptake in the right upper quadrant was located within the right lobe of the liver and was highly suggestive of liver metastasis, and the focus of uptake in the left upper quadrant corresponded to physiological activity within the stomach.

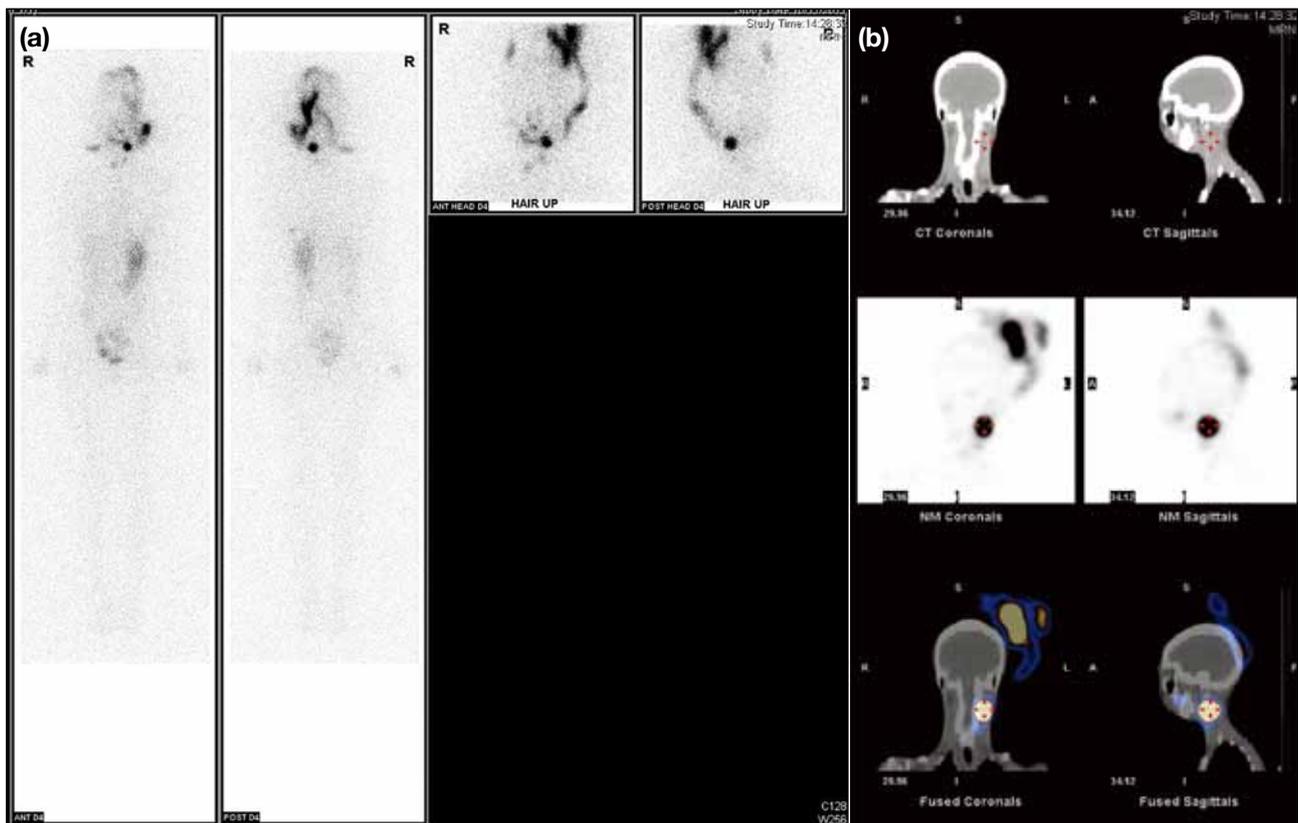
lymphadenopathy. However, there was equivocal uptake in the right and left upper quadrants of the abdomen. SPECT/CT fusion images were able to clarify that the focus of uptake in the right upper quadrant was located within the right lobe of the liver, which was highly suggestive of liver metastasis, and the focus of uptake in the left upper quadrant corresponded to physiological activity within the stomach. The decision was made to await the therapeutic effects of radioactive iodine and continue follow-up as scheduled.

A 54-year-old woman underwent thyroidectomy for papillary thyroid carcinoma. High-dose whole-body

scan was performed after a therapeutic dose of  $^{131}\text{I}$  (3 GBq) was administered. Whole-body biplanar images showed intense uptake in the neck that was suggestive of residual malignancy (Figure 7). There was also intense focal uptake in the left lower quadrant of an equivocal nature. Transaxial SPECT/CT fusion images revealed that the uptake in the left lower quadrant corresponded to an intraperitoneal metallic structure. This finding was consistent with unusual artefactual uptake by a metallic clip from previous tubal ligation surgery. Without correlative findings from SPECT/CT, the increased uptake in the left lower quadrant may have been falsely labelled as metastatic disease. The



**Figure 7.** (a) Whole-body biplanar images show intense uptake in the neck suggestive of residual malignancy and equivocal intense focal uptake in the left lower quadrant. (b) Transaxial SPECT/CT fusion images show that the uptake in the left lower quadrant corresponds to an intraperitoneal metallic structure.



**Figure 8.** (a) Whole-body biplanar images show intense uptake over the left side of the neck suggestive of persistent residual local metastasis; there was also unusual linear uptake over both sides of the head and neck region that did not correspond to any anatomic structures, so additional localised views of the head with her hair up were performed. (b) SPECT/CT fusion images confirmed local cervical nodal metastasis in the left neck, and that the unusual linear uptake corresponded to artefactual hair contamination.

patient continued follow-up as scheduled with close biochemical monitoring for disease status.

A 24-year-old woman underwent thyroidectomy and left neck dissection for papillary thyroid carcinoma. High-dose whole-body scan was performed after a second therapeutic dose of  $^{131}\text{I}$  (3 GBq) was administered for residual local malignancy. Whole-body biplanar images showed intense uptake over the left side of the neck suggestive of persistent residual local metastasis (Figure 8). There was also unusual linear uptake over both sides of the head and neck region that did not correspond with any anatomic structures. Additional localised views of the head with the patient's hair up were performed. SPECT/CT fusion images confirmed local cervical nodal metastasis in the left neck, and that the unusual linear uptake corresponded to artefactual hair contamination. The patient continued follow-up as scheduled to

await the therapeutic effects of radioactive iodine with consideration of a further therapeutic dose of  $^{131}\text{I}$  depending on subsequent disease status.

## CONCLUSION

SPECT/CT represents a useful diagnostic non-invasive imaging procedure that is simple to perform and provides excellent additional information over planar  $^{131}\text{I}$  scintigraphy. Therefore, the SPECT/CT system should be used more widely in the follow-up of thyroidectomised patients with differentiated thyroid carcinoma, particularly when planar imaging is not conclusive.

## REFERENCE

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